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FACT SHEET

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HIROSHIMA AND NAGASAKI OCCUPATION FORCES

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Introduction.

This Fact Sheet discusses the **current Department of** Defense (DoD) research effort into the postwar (1945-46) occupation of the Japanese cities of Hiroshima and Nagasaki by U.S. military forces. It outlines the circumstances and effects of the atomic bombing of those cities, the units involved in the occupation, their mission, the duration of their stay in Japan, the ionizing radiation exposure that individuals might have experienced as a result of residual radiation from the bombings, and the possible health risk that veterans of the occupation forces might experience as a result of those radiation doses.

DoD Research Program.

In 1977, as a result of growing national interest and concern over possible adverse health experiences of former servicemen who had participated in the atmospheric nuclear test program, 1946-62, DoD commenced an intensive, high-priority, multi-faceted program on behalf of these individuals. The program, termed the Nuclear Test Personnel Review (NTPR), involves detailed research into archives and data repositories nationwide; publication of a bookshelf of volumes comprising a personnel-oriented history of the atmospheric test program; declassification and reprinting of source documents; highly technical reconstruction of radiation dosages; wide-ranging public information programs aimed at establishing contact with former test participants; individual notification of participants who may have received radiation doses in excess of 5 rem, coupled with a program of free medical examinations; sponsorship of morbidity-mortality studies by the National Academy of Sciences to ascertain whether or not former test participants are experiencing adverse health effects that could be attributable to radiation exposure during the testing; and continuing assistance to veterans and the Veterans Administration (VA) on issues involving test participation, radiation exposure, and claims for VA compensation. The Defense Nuclear Agency (DNA) is the DoD executive agent for this NTPR program. It has been underway for over two years, and is estimated to require another two years for completion. It is adequately funded (about

$6 million per year) and is staffed at a level of about 170 man-years per year, including active NTPR teams in each Service. A separate DNA Fact Sheet on the NTPR program is available.

In 1979, when concerns arose that veterans of the postwar occupation of Hiroshima and Nagasaki might be experiencing adverse health effects, DNA expanded its on-going NTPR program to encompass these occupation veterans. Thus since the fall of 1979, DNA has been carrying out a detailed research program to recover, from records, historical documents, and interviews, all possible data pertaining to the possible radiation exposure of occupation troops. The Government is deeply concerned over the welfare of these veterans and is determined to ensure that the issue is fully investigated and that individual concerns receive rapid and thorough responses. This Fact Sheet summarizes our research to date.

The Wartime Bombings.

The bombings were carried out in early August, 1945. Their objective was to bring World War II to a quick end, and thereby avoid many months of fighting and continued destruction, and the deaths of an estimated million U.S. servicemen, an equal number of Allied servicemen, and a much larger number of Japanese, that would result from the planned invasion of the Japanese home islands. The targets in both Hiroshima and Nagasaki were military installations and war industries; and in both cases warnings and surrender ultimatums were given prior to the bombings. Several days after the bombings, the Japanese government indicated its willingness to surrender unconditionally, and the formal surrender took place on 2 September 1945, ending World War II.

The first atomic bomb was dropped on Hiroshima on 6 August 1945. It was a uranium-235 weapon, detonated about 1,670 feet above the ground, with a yield of about 13 kilotons (kt). Figure 1 is an outline map of Hiroshima, showing the built-up area of the city (shaded area), the hypocenter of the burst (the spot on the ground directly under the detonation), and the approximate perimeter of total destruction from blast and fire (dashed line). Figure 2 is a reproduction of a photograph illustrating the totality of devastation to Hiroshima inside this perimeter.

The second bomb was dropped on Nagasaki on 9 August 1945. It was a plutonium-239 weapon, detonated about 1,640 feet above the ground with a yield of about 23 kt. Figure 3 is an outline map of Nagasaki, showing the built-up area of the city (shaded area), the hypocenter of the burst (the spot on the ground directly under the detonation), and the approximate perimeter of total destruction from blast and fire (dashed line). Figure 4 is a reproduction of a photograph illustrating the totality of devastation to Nagasaki inside this perimeter.

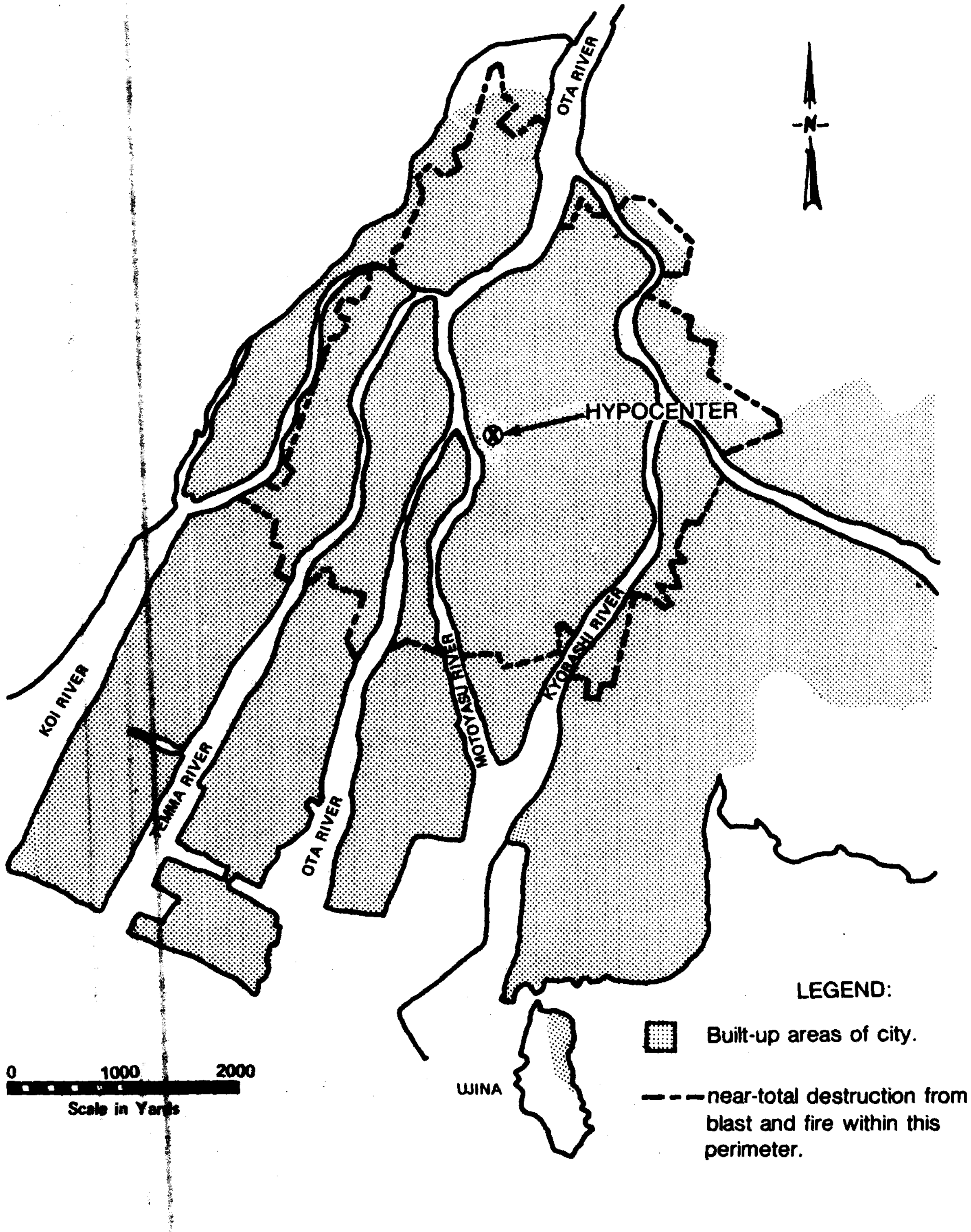

Figure 1

HIROSHIMA

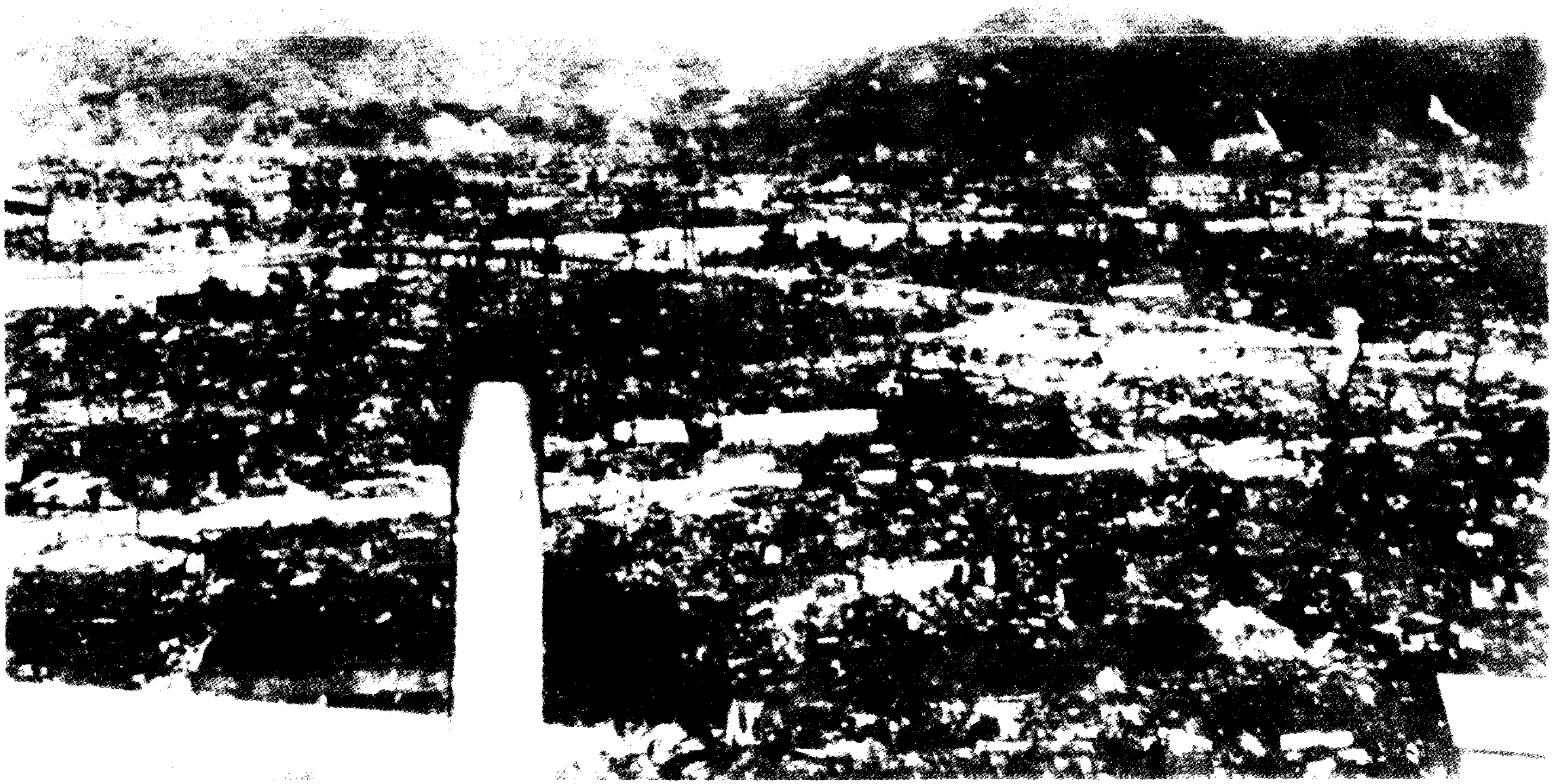

Figure 2. Hiroshima, looking across the Hypocenter

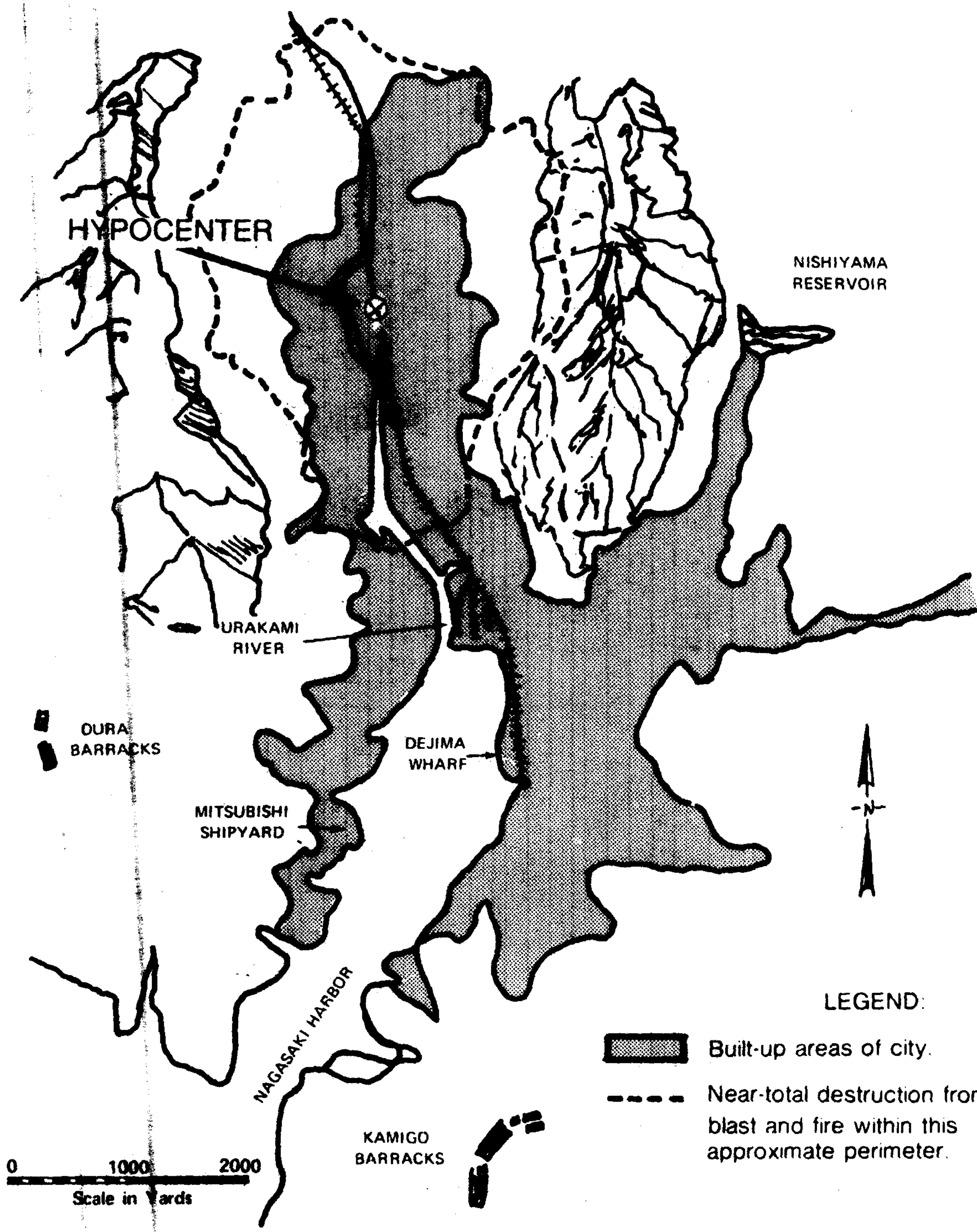

Figure 3

NAGASAKI

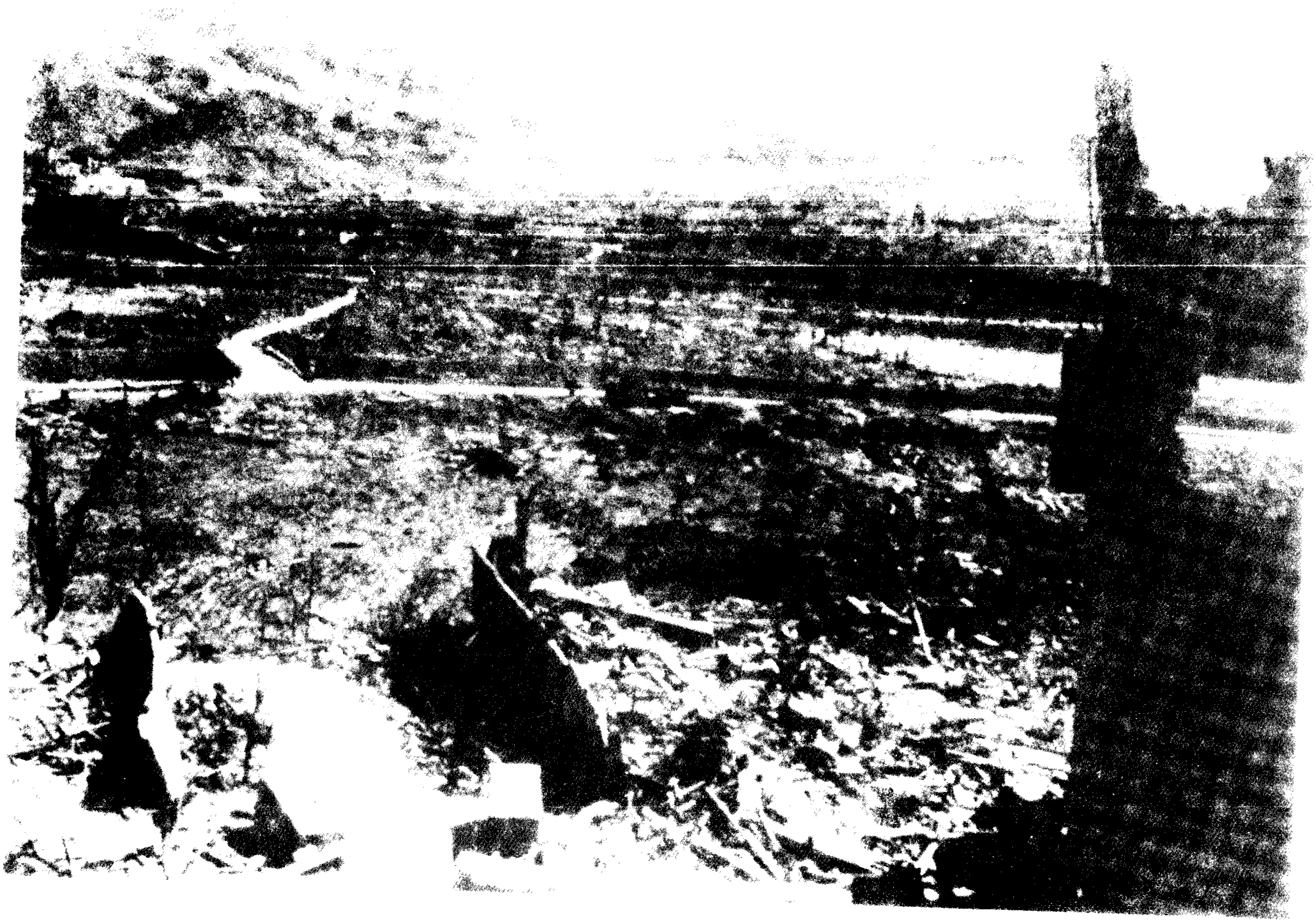

Figure 4. Nagasaki, looking across the Hypocenter

In terms of residual radiation, the effects in each city were similar. The burst altitude was so high that negligible residual radioactivity reached the ground in the vicinity of the hypocenter as local fallout. The detonation produced an instantaneous burst of gamma rays and neutrons and a fireball several hundred feet in diameter. Because the height of burst was 1600-1700 feet, the fireball's lower periphery was still a thousand feet or more above the ground at its maximum diameter. The fireball rose rapidly, at a rate of about 100 feet per second, accompanied by strong updrafts. On the ground, inrushing winds of high velocity entrained dust, converged on the burst point, and rose in a narrow column. These winds carried dust aloft, where it was mixed with the rising cloud of bomb residue. By the end of the first minute, the fireball had risen to a height of about one mile, had lost its brilliance, and was continuing to expand by mixing with the cooler surrounding air. The dust in the cloud became contaminated with the fission products and unfissioned material from the bomb as it continued to rise and mushroomed out at an altitude of several tens of thousands of feet. After some ten minutes the radioactive cloud reached its maximum height of 40,000-50,000 feet, all the while being blown downwind by the high-altitude winds. Initially, the radioactivity in this cloud was intense; however, as it was blown downwind over tens of thousands of miles it became quite dilute. Most of the radioactive particles eventually returned to earth over long periods of time as extremely low-level fallout covering much of the globe. However, at the local areas of the detonations themselves--that is, at the cities of Hiroshima and Nagasaki--the fission products, bomb residue, and contaminated dust were going up, not down.

Thus, in Hiroshima and Nagasaki, the high burst altitude was the key factor in preventing any significant residual contamination. Had either bomb burst on the surface, or at such a low altitude that the fireball reached the ground, it would have been a different story.

<u>Early Radiation Surveys.</u>

Immediately after the bombing a series of actions were undertaken to verify, through on-site surveys, that any residual radiation which might remain in the cities of Hiroshima and Nagasaki and their vicinity would not present a health hazard to occupation troops, or to continued habitation by the Japanese. The bombs had been planned as air bursts, thus it was anticipated that little residual contamination would remain in the vicinity after the detonations, and that whatever radiation there was would decay within days to very low levels. Scientific data taken at the time of the bombings showed that the detonations had occurred at the planned altitudes; however, U.S. authorities believed it essential to conduct radiation surveys of the cities themselves. An additional purpose of the surveys was the obtaining of scientific data on the effects of nuclear weapons.

- The first of these surveys was carried out on an urgent basis by scientists from the Manhattan District (the U.S. organization that had developed the bombs) under the leadership of General Farrell. With the forth-coming occupation by U.S. troops in mind, an August 12 message from General Marshall (U.S. Army Chief of Staff in Washington) to General MacArthur (the Theater Commander) emphasized the importance of getting the survey teams to the cities quickly ". . . in order that these troops shall not be subjected to any possible toxic effects, although we have no reason to believe that any such effects actually exist." The teams made rapid radiation surveys of Hiroshima on 8-9 September (a month before occupation troops arrived in that area), and of Nagasaki on 13-14 September (ten days before occupation troops arrived). They reported that there was negligible radioactivity. These "quick-look" reports served the critically important purpose of allowing occupation plans for these areas to proceed.

- A much more extensive survey was made a few days later by the Manhattan Project Atomic Bomb Investigating Group--some members of which had participated in the previous rapid surveys. This team of scientists made and recorded detailed measurements in Nagasaki from 20 September to 6 October, and in Hiroshima from 3 to 7 October, and filed extensive reports. These reports have been used over the subsequent years as basic source documents. All measurements showed the levels of residual radioactivity to be extremely low.

- A third series of on-site surveys was conducted a few days later by the Naval Technical Mission to Japan. This team surveyed Nagasaki during the period 15-27 October, and Hiroshima on 1-2 November 1945. The results of this extensive and well-documented survey corroborated the earlier conclusions that the residual radioactivity in and around Hiroshima and Nagasaki at the time the occupation forces arrived was so low as to present a negligible health hazard. These reports--like the previous ones--have been regarded over the years as basic source documents.

- These U.S. investigation teams also made use of data from numerous separate radiation monitoring surveys, soil and debris sampling programs, and other analyses conducted by Japanese scientists in the days and weeks immediately following the bombings. For example, from Tokyo Imperial University, Kyushu Imperial University, Kyoto Imperial University, Tokyo Institute of Physics and Chemistry, and other organizations, the following Japanese scientists were among those active in the initial surveys in 1945:

Takagi, Yamasaki, Sugimoto, Murati, Misonoo, Shinohara, Morita, Kohra, Masuda, Sakata, Nakane, Miyazaki. In some cases, copies of their reports were included in the above-mentioned U.S. reports. In other cases, they were published separately in Japan.

Some of the more extensive and pertinent of these early U.S. and Japanese reports are cited in the first section of "Selected References" at the end of this Fact Sheet.

Residual Radiation in Hiroshima and Nagasaki.

After the bombings there remained one area of low-level residual radioactivity in each city, and one area in the nearby vicinity of each city. The contamination in the cities themselves was caused by one mechanism, that outside the cities by another. The first type of residual radiation--which formed a roughly circular area around the hypocenter--was "induced radioactivity." The second type, which occurred downwind outside the city, was caused by "rainout" (a process similar to fallout). The following two sections describe each in turn.

Induced Radioactivity at the Hypocenters.

This pattern of residual radiation was created at the moment of detonation, when the high-intensity burst of neutrons from the bomb encountered atoms of normally non-radioactive elements in the soil and building materials (concrete, metal, tile, etc.) in the area beneath the detonation and caused them to become radioactive. Examples of elements in which radioactivity can be induced are aluminum, sodium, manganese, scandium, cobalt, and cesium. This induced radioactivity was of relatively low intensity, because of the relative scarcity of these elements. Furthermore, as in all radioactive materials, the intensity of radiation emitted continuously declined over time (that is, the elements became less radioactive). Many of these elements had short half-lives (the time required for the radiation intensity to be reduced from any given value to one-half that value). For example, aluminum-28 has a half-life of 2.3 minutes, sodium-24 has a half-life of about 15 hours, and manganese-56 has a half-life of about 2.6 hours. Because of these short half-lives, the decay in intensity of radiation in the relatively circular pattern of induced radioactivity around each hypocenter was relatively rapid.

Numerous experiments have been conducted over the years to verify the patterns of induced radioactivity measured at Hiroshima and Nagasaki. Nuclear weapons of comparable yield have been detonated at about the same altitudes at the Nevada Test Site, producing patterns of induced radioactivity quite similar to those measured in Hiroshima and Nagasaki. Likewise, Japanese roofing tiles, construction materials, and soil samples taken from Hiroshima and Nagasaki have been exposed experimentally to neutron bombardment similar to that produced by the wartime bombs, and the results have been compared to those measured in the bombed cities. Thus the mechanism of induced radiation is well understood.

In Hiroshima, when the first occupation troops arrived in the vicinity about 60 days after the bombing (see section below on Hiroshima occupation), the intensity of this induced radioactivity near the hypocenter had decayed to negligible levels. Figure 5 is a reproduction of the Hiroshima outline map shown in Figure 1, with a typical contour of induced radiation overlaid upon it. The pear-shaped outine of dots around the hypocenter on Figure 5 shows the iso-intensity contour of 0.03 milliroentgen per hour.*

Three points might be mentioned to put this low-level residual radiation in context. First, it covers a relatively small area of the city around the hypocenter. Second, it is centered in the area of maximum physical destruction from blast and fire. As can be seen from Figure 2, virtually nothing was left standing in the area where residual radiation existed. Third, the residual radiation intensity was extremely low-level. For example, if this contour of 0.03 milliroentgen per hour is taken as an average value of induced radioactivity in the vicinity of the hypocenter at the time of the troops' arrival, an individual working in this area for an eight-hour day would be exposed to 0.24 milliroentgen per day (0.03 x 8). Radioactive decay would reduce this exposure rate each subsequent day, but if this decay is disregarded for ease of calculation, in a month this individual would be exposed to approximately 7.2 milliroentgen (0.24 x 30). In a three-month period, which is a longer time than any U.S. military occupation unit remained in the vicinity of Hiroshima, the maximum total exposure of the individual working daily at the hypocenter would be about 22 milliroentgen (7.2 x 3). The dose received would be less than one two-hundredth of

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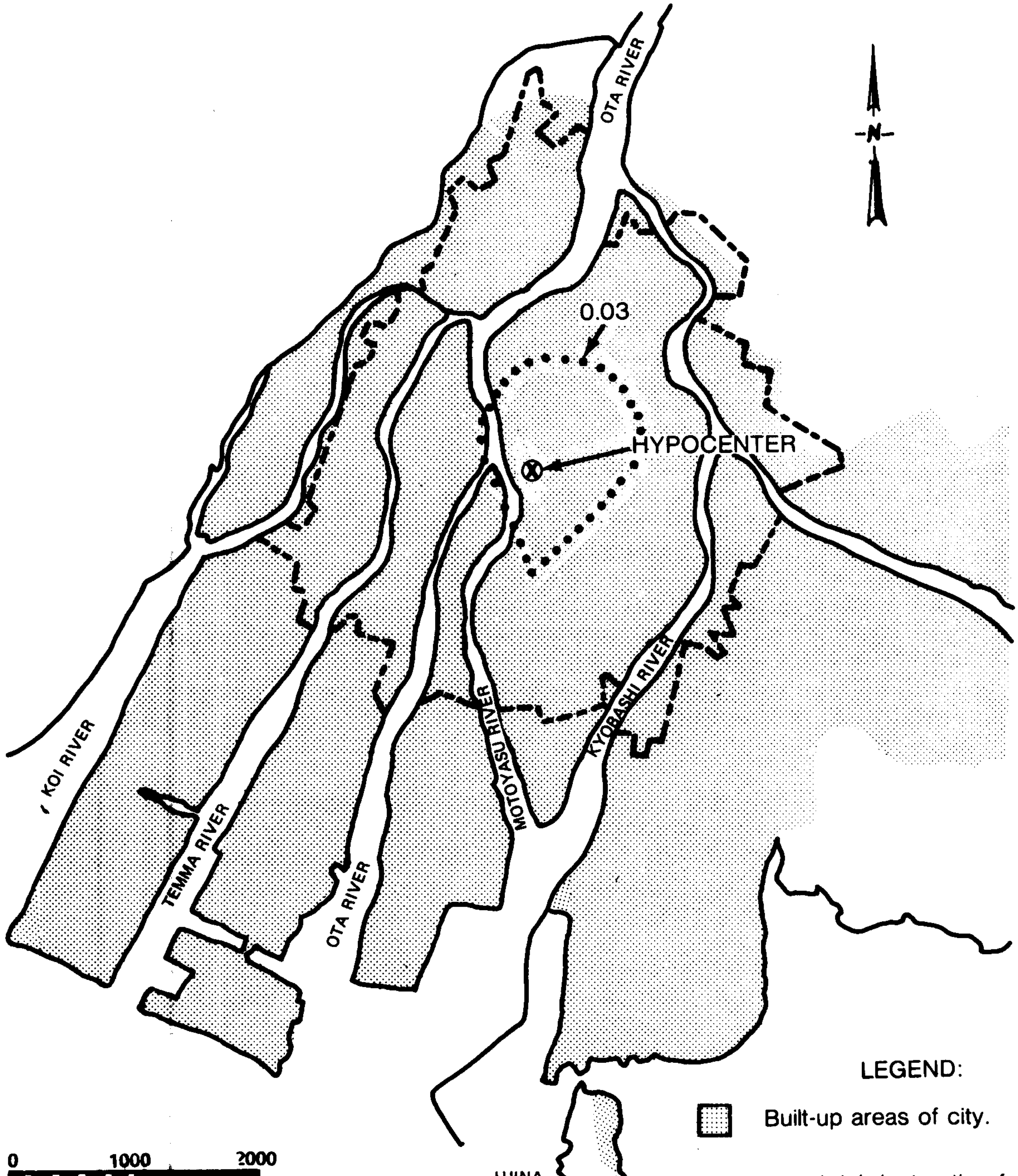
*Three units are commonly used in describing radiation levels. The Roentgen is a unit of exposure, a measure of radiation energy in air. (A milliroentgen--the unit used in this paper--is a much smaller measure, equal to one-thousandth of a Roentgen.) The rad is a unit of absorbed dose, a measure of radiation energy deposited in the body. The rem is a unit of dose equivalent, which adjusts the absorbed dose (in rads) for the relative effectiveness of the particular radiation. For example, exposure of an individual to one Roentgen of gamma radiation results in a dose of approximately 0.65 rem at the center of the body. Today's Federal guidelines allow radiation workers to receive a dose of 5 rem per year, more in some cases. A millirem, the measure of dose used in this paper, equals one-thousandth of a rem. Thus, under national (and most international) standards today, a radiation worker is permitted to accumulate a dose of 5,000 millirem per year.



LEGEND:

Built-up areas of city.

- - - near-total destruction from blast and fire within this perimeter.

• • • • Radiation contour of induced radiation (in milliroentgen per hour) 3-7 Oct 1945.

Figure 5

HIROSHIMA

today's allowable annual dose for radiation workers under Federal guidelines. It is also only a small fraction of the radiation dose each individual on earth receives annually from natural sources (cosmic and terrestrial radiation). For example, every resident of the U.S. receives a dose of about 100-400 millirem per year from naturally occurring radiation.

The maximum extent of the induced radiation at Hiroshima--that is, the circle of greatest diameter around the hypocenter at which any level of radioactivity above the natural background could be detected--was well inside the perimeter of near-total destruction shown by the dashed line on Figure 5. The highest intensity of radiation in the soil directly under the hypocenter at the time the occupation troops arrived in the vicinity was about 0.1 milliroentgen per hour. Thus, while there was residual radiation in Hiroshima, it covered a small area at the center of the physical devastation and its intensity--which was steadily declining--was so low as to be negligible.

At Nagasaki, when the main body of occupation troops entered the city 45 days after the bombing (see section below on Nagasaki occupation), the residual radiation pattern from induced radioactivity around the hypocenter was as shown by the small pear-shaped outline of dots on Figure 6. As in the case of Hiroshima, virtually no residue from the bomb reached the ground in the vicinity of the hypocenter, and the low-level residual radioactivity that was measured by the numerous teams of Japanese and U.S. scientists was induced in normally non-radioactive substances by the intense burst of neutrons released at the instant of the bomb's detonation.

The area of induced radioactivity was somewhat smaller than that at Hiroshima. The contour shown is an iso-intensity line of 0.03 milliroentgen per hour. (Refer to the previous paragraph on induced radioactivity in Hiroshima for a discussion of the meaning and import of this very low level of radioactivity.)

The outermost perimeter of measurable induced radioactivity at Nagasaki was still well within the area of total destruction; and the "hottest" spot in the soil at the hypocenter itself had an intensity of less than 0.1 milliroentgen per hour. Thus, as in the case of Hiroshima, the only area that showed any radioactivity whatsoever at the time of arrival of the occupation troops was very small in size, was located at the center of the area of maximum destruction from blast and fire, where little or nothing was left standing (see Figure 4), was of such a low level as to be virtually negligible, and was decaying to a lesser intensity every day.

"Rainout" Radioactivity Downwind of the Cities.

In the vicinity of each city there was a second pattern of residual radioactivity produced by a different mechanism. As the radioactive cloud was borne downwind, rainshower activity within an

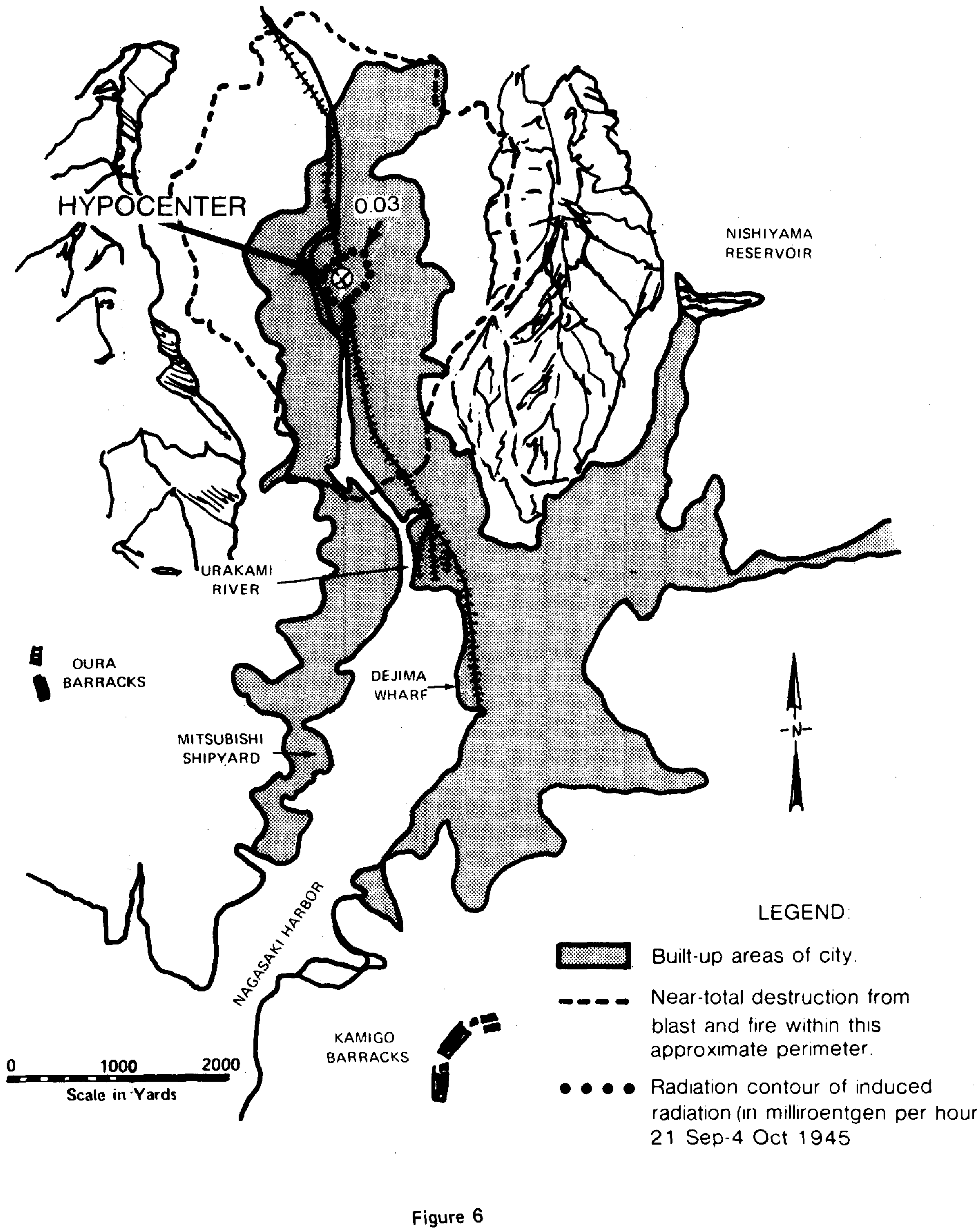


Figure 6

NAGASAKI

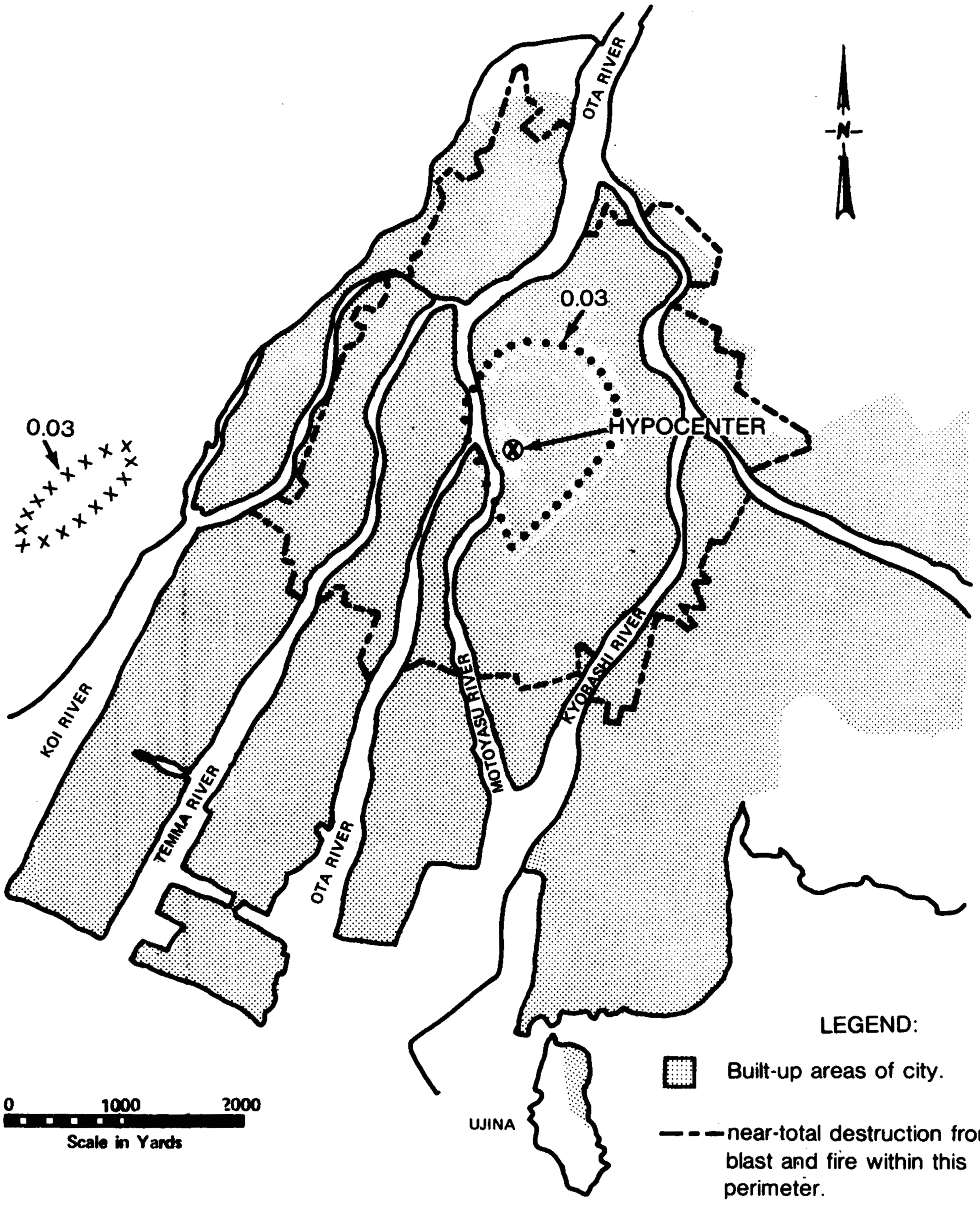
hour after the detonation caused fission products and unfissioned residue of the bomb to be carried to earth in a manner similar to fallout. This "rainout" produced a small pattern of radioactivity to the west of Hiroshima, near the village of Takasu; and a somewhat larger area to the east of Nagasaki, in the vicinity of the Nishiyama Reservoir.

The fission products and unfissioned residue of a nuclear weapon, when deposited on the ground, contain a mixture of hundreds of different radioisotopes, each decaying at its own rate according to its half-life. The overall decay rate of the entire mixture is very rapid. For several months after the detonation, this drop in radioactivity occurs at the rate of $T^{-1.2}$, where "T" is time in hours. As a rough rule-of-thumb, this means that if you start with a given intensity of radioactivity one hour after the detonation (H + 1), seven hours later the intensity of radiation would have dropped to one-tenth its former level. Two days after the detonation, the intensity of radiation would have decayed to about one-hundredth of its H + 1 value. Two weeks after the detonation the intensity of radioactivity in the fallout pattern would have dropped to one-thousandth of its H + 1 value. Thus, since the occupation troops arrived in the vicinity of Hiroshima more than eight weeks after the bombing, and in Nagasaki more than six weeks after that detonation, the intensity of the residual radiation in the Takasu area near Hiroshima and in the Nishiyama area near Nagasaki had dropped by a factor of many thousands from its intensity one hour after the bombings.

The small rainout pattern to the west of Hiroshima is shown in Figure 7 by an iso-intensity contour of 0.03 milliroentgen per hour (the oval of "x's"). At the time the occupation troops arrived in this part of Japan, the "hottest" spot in the center of this oval had an intensity less than 0.05 milliroentgen per hour.

The pattern of residual radioactivity caused by rainout near the Nishiyama Reservoir, east of Nagasaki, is shown in Figure 8. The area here is somewhat larger, and it has slightly greater intensity. The contour of "x's" shown is the approximate outline of the 0.1 milliroentgen per hour perimeter. Outside of this contour, the intensity falls to background levels very quickly in the reservoir area and in the direction of Nagasaki. Inside this contour, the intensity rises gradually to reach about one milliroentgen per hour at the "hottest" spot at the time of the troops' arrival.

Thus, of the four patterns of measurable residual radioactivity remaining in Japan at the time of arrival of the occupation troops, the most significant was in the vicinity of the Nishiyama Reservoir outside Nagasaki. It was also the only one of the four which included slight levels of plutonium in the radioactive mixture. This area, however, was remote and rugged, characterized



LEGEND:

Built-up areas of city.

- - - near-total destruction from blast and fire within this perimeter.

• • • • Radiation contour of induced radiation (in milliroentgen per hour) 3-7 Oct 1945.

x x x x Radiation contour of "rainout" radiation (in milliroentgen per hour) 3-7 Oct 1945

Figure 7

HIROSHIMA

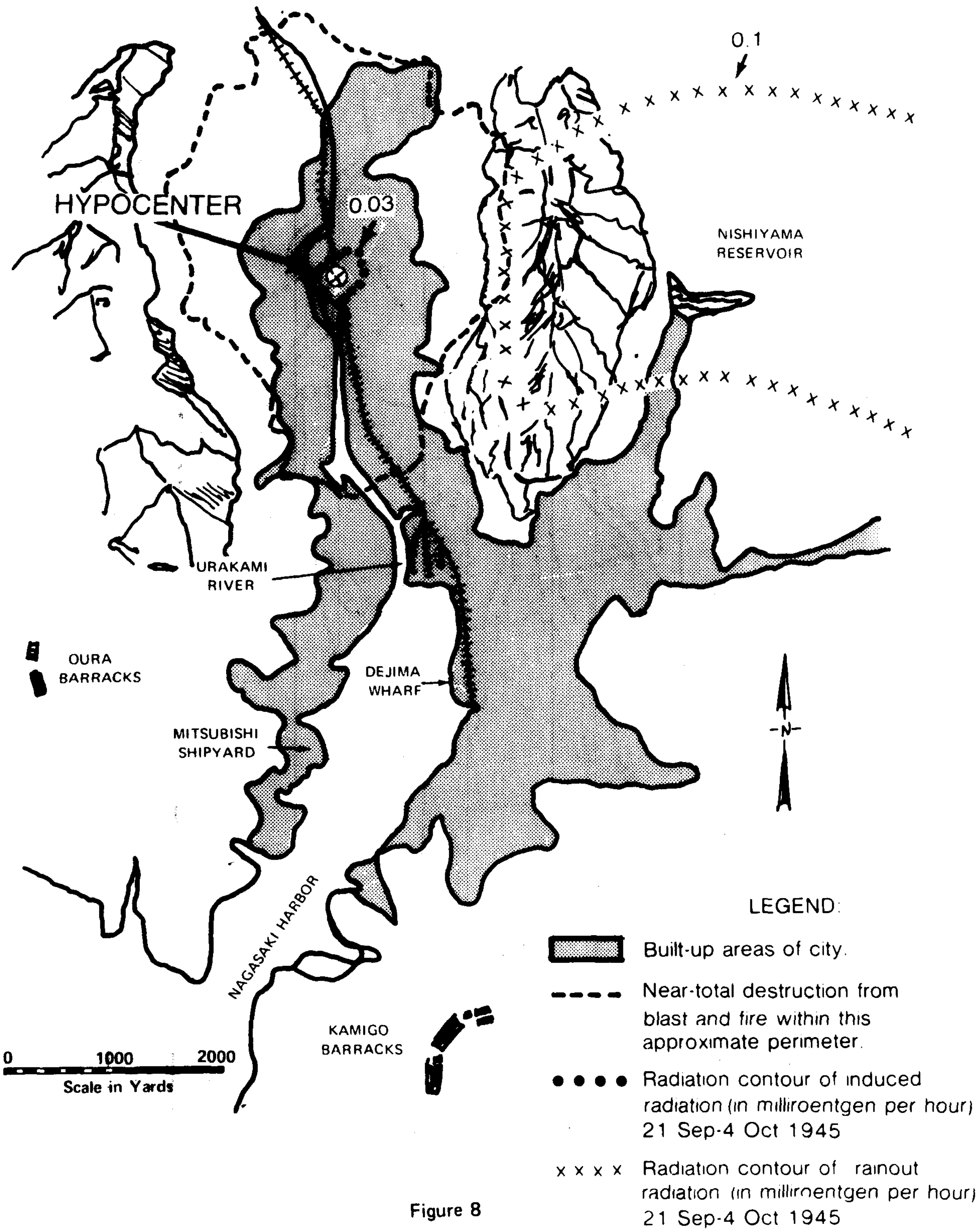


Figure 8

NAGASAKI

by steep slopes and heavy forests, with few trails or roads and even fewer buildings. Thus the Japanese population of the area was sparse, there were no occupation forces stationed in the vicinity, and there was little need for military patrols into the area.

One final comment should be made about the intensity of residual radioactivity--applying to the two patterns at Hiroshima and the two at Nagasaki. In addition to the rapid natural decline in radiation intensity through radioactive decay, the reduction in contamination was aided by the heavy rains that fell over southern Honshu and Kyushu that fall. In fact, Hiroshima experienced a severe typhoon in September 1945. Between the bombings and the time occupying troops arrived in the vicinity, approximately 62 centimeters (24 inches) of rain had fallen in Hiroshima, and 82 centimeters (32 inches) in Nagasaki. The heavy rainfall continued during the occupation, and by 1 November the cumulative total since the bombing had been 91 centimeters (36 inches) in Hiroshima and 122 centimeters (48 inches) in Nagasaki. This heavy rainfall washed away some of the residual radioactivity.

The Occupation of Japan.

As soon as the bombs were dropped and the Japanese gave indications of accepting the Allies' surrender terms, planning for the occupation of Japan was carried out intensively. The mission of the occupation troops was to establish control of the home islands of Japan, ensure compliance with the surrender terms, and demilitarize the Japanese war machine.

The mission did not include the "cleanup" of Hiroshima, Nagasaki, or any other areas, nor the rebuilding of Japan. These functions were carried out by the Japanese. In some cases, U.S. occupation forces had to repair a specific building for interim use, make an airfield operational, or clear a specific road for access; however, even in these cases, Japanese labor was generally used.

The occupation of the western portion of Honshu Island (which contains Hiroshima) and the southern Japanese islands of Kyushu (where Nagasaki is located) and Shikoku was the responsibility of the Sixth U.S. Army, which was composed of the I and X Army Corps and the V Amphibious Corps (Marines). Each Corps was made up of three divisions and supporting units. The occupation force for this portion of Japan totalled some 240,000 troops.

The basic organization chosen to accomplish the occupation mission was the infantry regiment, and the concept was to assign a regiment to each prefecture (similar to a U.S. county) within

Japan. The regimental commander was responsible for taking control of all Japanese military installations in his area, and for disposing of all weapons, ammunition, and military equipment (by destruction; by scrapping and returning to Japanese civil control; by shipping to the U.S. for training use, trophies, souvenirs; etc.). He was responsible for supervision of demobilization of the Japanese armed forces, for security of materiel throughout his assigned area, and for ensuring compliance with the surrender terms. In general, the mission was relatively easy to carry out because the Japanese were compliant and cooperative. Japanese military commanders were helpful and thorough in submitting lists of all installations and inventories of material, as well as in carrying out demobilization. Japanese police were effective in maintaining order among the Japanese and in providing laborers for heavy work.

The occupation situation in Hiroshima was quite different from that in Nagasaki, principally because the excellent harbor at Nagasaki had not been extensively mined and was immediately usable. Thus, Nagasaki became a primary staging area for insertion and withdrawal of occupation forces. This was not the case with Hiroshima, whose harbor had been heavily mined and thus was unusable for an extended period. Because of this, more occupation troops passed through Nagasaki, and more were stationed in its vicinity, than was the case for Hiroshima.

Another difference was that the occupation force at Hiroshima was composed primarily of Army troops, while that at Nagasaki was composed mostly of Marine Corps units, with small supporting Navy and Army elements.

As a general observation, it can be stated that throughout the occupation of Japan the troop situation changed continually. At the time of their initial assignments, units were virtually on a wartime footing. It quickly became apparent that this high troop density was not needed, because of the total cooperation of the Japanese. Additionally, pressures for demobilization of U.S. troops increased rapidly, and there was a desire to reduce troop commitments as rapidly as possible. "High point men"--those with longest service and thus most deserving of early discharge--were returned to the United States, and unit strengths were kept at adequate levels by reassignment of low point men between units. As entire units were deactivated or returned home, the area of responsibility of nearby units expanded rapidly. As some areas in Japan were stablized more rapidly than others, units were transferred from one assignment and location to another on short notice. The overall strength of the U.S. occupation forces dropped dramatically each month. Thus the duration of assignment of any individual or any unit in the occupation forces was quite short.

Hiroshima Occupation.

The occupation of western Honshu was assigned to the I and X Corps of the Sixth Army. Within the X Corps, responsibility for the prefectures in the vicinity of Hiroshima and Kure (about 11 miles southeast of Hiroshima) was initially assigned to the 41st Division. On 6 October 1945 units of the 41st Division landed at Hiro, about 15 miles southeast of Hiroshima, and secured the Kure Naval Yard. On 7 October the 186th Infantry Regiment of the 41st Division landed, and the Regiments's 2nd Battalion established headquarters and billets in Kaidaichi, about 5 miles southeast of the center of Hiroshima (well off the map in Figure 7). Since the city of Hiroshima had been almost totally destroyed by the bomb, no major units were stationed there throughout the occupation. One of the first actions the 186th Infantry Regiment carried out--on 7-8 October--was to set up a roadblock in the vicinity of Kaidaichi to prevent entry into Hiroshima by military personnel.

During the next two months, units of the 186th Infantry Regiment conducted reconnaissance patrols and other specific daily assignments throughout its area of responsibility, which included the city of Hiroshima. Thus it is reasonable to assume that individuals of the 186th Infantry Regiment made occasional patrols into the destroyed area of Hiroshima. Additionally, it seems reasonable to assume that individuals from any nearby units of the 41st Division who were able to obtain leave papers or passes might have made brief sightseeing trips there to view the destruction caused by the bomb. (On a typical patrol or sightseeing trip to the center of the bomb-devastated area, the maximum dose received should be less than 0.1 millirem.)

In December 1945 the 41st Division (including the 186th Infantry Regiment) was deactivated; and individuals were either returned to the United States for discharge or transferred to other units elsewhere in Japan.

Upon deactivation of the 41st Division the 24th Division took over their responsibilities in the vicinity of Hiroshima. The 34th Infantry Regiment of the 24th Division relieved the 186th Regiment of the 41st Division, and units of the 34th moved into the rehabilitated buildings, hotels, and private residences in Kaidaichi originally used by units of the 186th. The responsibilities of the 34th Regiment covered such a wide geographic area that eventually only one company--"G" Company of the 2nd Battalion--was stationed in the vicinity of Hiroshima. The Company was quartered in Ujina, a small island in the delta area just south of the city (see Figure 7).

On 6 March 1946 the 34th Regiment of the 24th Division was relieved by an Australian Infantry Battalion of the British Commonwealth Occupation Forces, and the U.S. occupation in the vicinity of Hiroshima came to an end.

Nagasaki Occupation.

The occupation of Nagasaki involved many more troops, and its history is much more extensively documented in Marine Corps records. Only those aspects pertaining to the issues at hand will be summarized here.

Prior to the actual occupation, two operations took place in Nagasaki during the period 11-13 September 1945. First, Nagasaki was used as a processing point for the repatriation of former prisoners-of-war who had been held in Japanese prison camps on the island of Kyushu. During this twelve-day period more than 9,000 Allied former POWs were moved through Nagasaki for evacuation to hospital ships awaiting in the harbor. A POW recovery team and a detachment of Marine guards were ashore in Nagasaki during this twelve-day period to accomplish this function. The harbor at Nagasaki was ideal for this purpose because of its location, its natural shelter, and its deep water. In spite of the devastation to the northern portion of the city, Nagasaki was feasible for use because the relatively great distance from the hypocenter to the waterfront (see Figure 8) caused the harbor area (docks, cranes, warehouses, buildings) to escape most of the destructive effects of the bomb and to be completely free from radioactivity.

Second, a small advance party of the occupation force (about 12 personnel) arrived in Nagasaki on 16 September and remained until the main force arrived on 23 September 1945.

The occupation of the Nagasaki area was assigned to the 2nd Marine Division, a unit of the V Amphibious Corps. The Division and its supporting units had a strength of about 20,000 personnel at the beginning of the occupation. The four principal combat units of the 2nd Marine Division were the 2nd, 6th, and 8th Regimental Combat Teams (RCTs) and an Artillery Group composed principally of the 10th Marine Regiment. The other units in the 2nd Marine Division were a Headquarters Battalion, Service Troops, an Engineer Group, a Tank Battalion, an Observation Squadron, and some smaller organizations.

Upon landing, the 8th RCT and the 10th Marine Regiment deployed immediately to Isahaya, some 10 miles north of Nagasaki. The 8th RCT had no involvement in the occupation of Nagasaki; and the 10th Marine Regiment did not return to Nagasaki until November.

The other elements of the 2nd Marine Division, numbering upwards of 10,000, debarked in the vicinity of the Dejima Wharf and the Mitsubishi shipyard (see Figure 8) and established command posts and billets in the vicinity. For example, the 2nd RCT landed on 23 September at Dejima Wharf, was billeted in the Kamigo barracks (see Figure 8), and established a command post at that location. The Team's zone of occupation included the east side of Nagasaki harbor and most of the nearby prefecture east of the Urakami River. The 6th RCT landed on 23 September in the Mitsubishi shipyard area, established a command post in that area, and was billeted in barracks at Oura (see Figure 8). The Team's zone of occupation included the west side of Nagasaki harbor and most of the nearby prefecture west of the Urakami River.

Over the next weeks and months there was a steady drawdown in the strength of the Division, as high point men were sent to the U.S. for discharge. There were also reassignments of areas of responsibility, as the 2nd Division took over areas that had previously been assigned to other units which departed. The 2nd RCT left Nagasaki in early November, and the 6th RCT departed in December 1945 along with two-thirds of the Engineer Group. The Headquarters Battalion and portions of the Service Troops left the Nagasaki area in January 1946. The Tank Battalion, which had landed and remained in Fukahori, about 9 miles southeast of Nagasaki, arrived in Nagasaki in November and departed in December 1945. The 10th Marine Regiment returned to Nagasaki from Isahaya in November 1945. This Regiment initially took over the responsibilities of the 2nd RCT, and soon the responsibilities of the 6th RCT as well.

The final units of the 2nd Marine Division--portions of the Service Troops, the last of the Engineer Group, and the 10th Marine Regiment--departed Nagasaki in June 1946, and the U.S. Marine Corps occupation of Nagasaki came to an end.

The strength of the 2nd Marine Division in Nagasaki is estimated to have remained above 10,000 for about the first three months of the occupation, through November 1945. For the next three months, through February 1946, Division strength in this area averaged about 5,000-7,000. For the last four months of the occupation, through June 1946, Division strength in Nagasaki was 3,000-4,000.

The specific billet locations of all units of the Division have not yet been precisely located, but without doubt they were in areas well clear of the hypocenter. Not only did the massive destruction of the blast and fire make that area uninhabitable (see Figure 4), but historical documentation shows that that area was avoided. For example, Volume V of the Marine Corps' "History of the U.S. Marine Corps Operations in World War II" states: "At 1300 on 23 September, the Second and Sixth Marines landed simultaneously on the east and west sides of the harbor. The two regiments moved out swiftly to occupy the city and curtain off the atom-bomb-devastated area."

Unquestionably there would have been occasions during the Nagasaki occupation on which patrols or other groups entered the areas of residual contamination to carry out specific missions. Also--as in the case of Hiroshima--it is reasonable to assume that individuals from units stationed nearby, who could obtain leave papers or passes, would have made brief sightseeing trips to the hypocenter to view the devastation caused by the bomb. (The maximum dose received on such a sightseeing trip should be less than 0.1 millirem.)

The U.S. Navy played a major role in transporting the Marines to Nagasaki and in evacuating POWs, but its role ashore was limited. During September 1945 some 136 Navy ships with about 34,000 crewmen arrived in Nagasaki harbor, generally docking at Dejima Wharf. Typical duration in port was three days, with cargo offload proceeding at maximum pace. Only a few ships, such as the hospital ship HAVEN (which was in port for 2-3 weeks), stayed longer. Ship traffic declined in subsequent months, with only 27 ships arriving in October.

Approximately 1100 Navy hospital corpsmen, a small number of medical and dental officers and chaplains, and an 800-man Construction Battalion, went ashore in Nagasaki assigned to 2nd Marine Division units. These Navy personnel left Nagasaki over the subsequent months--by reason of individual discharge or unit reassignment--at much the same rate as the Marines.

Atomic Bomb Casualty Commission.

Before proceeding to dose reconstructions, it is appropriate to discuss the remarkable research organization formed by Japanese and U.S. scientists shortly after the war and continuing to this day. In the previous section entitled "Early Radiation Surveys" it was mentioned that three U.S. and many Japanese teams of scientists made detailed, immediate surveys of the radiation environment and the effects of radiation upon the Japanese residents. These surveys commenced immediately after the bombings and continued for several months. Soon, a Japan-U.S. Joint Commission was organized, and detailed scientific investigations of the acute effects of the bombings were carried out. Based on the success of this early joint effort, President Truman in 1946 directed the National Research Council of the National Academy of Sciences to undertake a long-range study of the biological and medical effects of the atomic bomb on man. In response, the Academy organized "Atomic Bomb Casualty Commission (ABCC)" to continue this effort, commencing in 1947. The Japanese National Institute of Health (JNIH) began participation in the ABCC program in 1948, and it has continued to this date. In 1975, after 27 years of effective research, the Organization was re-established as the "Radiation Effects Research Foundation" (RERF), an incorporated foundation, managed and financed equally by the Governments of Japan and the U.S. The National Academy of Sciences continues directing RERF activities for the U.S.

The objectives of the ABCC/RERF are to conduct extensive, continuing, long-term studies into the effects of exposure to ionizing radiation in the survivors of the Hiroshima and Nagasaki bombings. To conduct this research, the ABCC/RERF maintains permanent research organizations in both Hiroshima and Nagasaki made up of medicine, clinical, pathology, radiology, statistics, and medical sociology departments. Over the past 32 years, the ABCC/RERF has published and distributed well over a thousand technical reports, and has made its findings even more widely available through publication in both English and Japanese versions of numerous medical and scientific journals.

The information thus published constitutes the most extensive and authoritative data available for the determination of radiation effects of the bombings, and of the overall risks of radiation-induced malignancy. Representative citations to this extensive body of scientific data are included under "Selected References" at the end of this Fact Sheet.

In summary, few world events have been as thoroughly documented at the time and as intensively and continuously studied by as many different groups of scientists as the atomic bombings and related radiation exposures at Hiroshima and Nagasaki. Thus--thanks to the ABCC/RERF--the patterns of residual radioactivity in Hiroshima and Nagasaki are well understood, and it is this large body of scientific material which is used by DNA and the Government in making current assessments of radiation-related issues.

Dose Reconstructions.

In order to be responsive to veterans, the VA, and others who are interested in the total dose received by veterans of the Hiroshima and Nagasaki occupation, DNA, with contractor support, has performed detailed dose reconstructions for the occupation forces. These dose reconstructions are based upon: (1) The patterns of residual radioactivity which were measured, documented, and published shortly after the bombings; (2) the extensive review and analysis of this residual radioactivity in the ensuing decades by the ABCC/RERF; and (3) the documented arrival and departure dates of each Army and Marine Corps unit which operated in the vicinity of Hiroshima and Nagasaki.

These dose reconstructions take into account: (1) The external dose of gamma radiation which would have been received by anyone venturing into the four areas of residual contamination described in the earlier sections of this paper; (2) the possible internal dose of radiation that might have been received by anyone inhaling dust containing contaminated particles; and (3) the possible internal dose that might have been received by anyone drinking water containing dissolved or particulate radioactivity from the Nishiyama Reservoir.

Because we cannot track the exact movements of every individual for each day he was in Japan, it is necessary to base the dose reconstructions upon a "worst case" analysis. In this type of analysis, one makes assumptions about movements, assignments, living patterns, etc. which would maximize the dose received. Since the dose reconstructions involve quite a number of these assumptions, all of which employ not the "best estimate" but rather the extreme end of the range of probable actions, the result is not the dose that the individual with the highest exposure received, but rather a hypothetical extreme which in all probability no individual even approached.

Some typical assumptions used in making these "worst case" dose reconstructions are as follows:

- It is assumed that the individual was the first man of his unit to arrive in Hiroshima or Nagasaki and the last man to depart.

- It is assumed that the individual was assigned daily duties--seven days a week, from day of arrival to day of departure--at the "hottest" spot in the hypocenter or in the downwind "rainout" area.

- It is assumed that the individual worked a full eight-hour workday in that "hottest" area of the hypocenter (four hours per day for the "rainout" areas outside the built-up portion of the city, where there were no military activities of interest and patrol travel time was greater).

- For inhaled dose, it is assumed that aerodynamically resuspended particles had a size distribution that was optimum for inhalation and retention in the body.

- For inhaled dose, it is assumed that dust resuspension factors were those appropriate to desert areas.

- For ingested dose (Nagasaki), it is assumed that all fission products reaching the Nishiyama Reservoir were soluble.

- For ingested dose (Nagasaki), it is assumed that all drinking water for an individual during his tour in Japan came from the Nishiyama Reservoir.

Using these, and similar, "worst case" assumptions, the dose reconstructions show that the maximum radiation dose any member of the U.S. occupation forces in Japan could have received--considering his external dose, his inhaled dose, and his ingested dose--was less than one rem.

It should be reemphasized that these "worst case" dose reconstructions do not mean that any individual received close to one rem. Rather, the highest dose received by any individual in the occupation force was more likely in the tens of millirem; and the average dose received by individuals in the Hiroshima and Nagasaki occupation forces was probably very close to zero.

The reasons why no individual would have approached the upper end of the "worst case" dose reconstructions of "less than one rem" can be seen in the following observations about the assumptions for the dose reconstructions:

- Divisions, regiments, etc., were assigned responsibilities throughout the prefectures, areas many times larger than the area of the cities; however, the dose reconstructions assumed the individual was assigned to the cities themselves.

- Even within the cities, less than one percent of the built-up area of each city was contaminated at a dose rate greater than 0.1 milliroentgen per hour; however, the dose reconstructions assumed the individual spent his full workday every day within that one percent of the city's area.

- Related to the above assumption is the fact that there would have been no reason for a member of the occupation forces to be assigned duties at these "hot spots." Figures 2 and 4 suggest how pointless such an assignment would have been at the hypocenters; and there were no activities going on in the "rainout" areas that would have caused the assignment of an individual. However, the dose reconstructions assume the individual was at the "hot spots," regardless.

- Even should patrols have been ordered to these "hot spots" for specific tasks, there would have been no rationale for assigning full eight-hour (or four-hour) workdays in these areas; however, the dose reconstructions assume the full-time assignment.

- Specific patrol and guard assignments would undoubtedly have been rotated among unit members; however the dose reconstructions assume the same individual is assigned each day to the "hot spot."

- If contaminated particles were resuspended with dust, many particles would be too large (in micron diameter) for inhalation; however, the dose reconstructions do not reduce the inhaled dose for this factor.

- With one or two minor, brief exceptions, there is no indication of U.S. occupation forces being involved in, or in the vicinity of, significant dust-producing activity; however, the dose reconstructions assume that this occurred continuously.

- The torrential rains, and the resulting ever-present mud (which figures prominently in historical accounts), would have inhibited dust formation; however, the dose reconstructions assume desert conditions.

- A significant portion of any fission products which reached the Nishiyama Reservoir would have been insoluble, and thus would have been deposited in the reservoir sediment or trapped in the filtration process; however, the dose reconstructions do not reduce the ingested dose for this factor.

- The Marine troops at Nagasaki imported their drinking water from Saipan for the first three weeks; however, the dose reconstructions assume they drank local water from the time of their arrival until their departure.

- Five or six drinking water systems supplied Nagasaki (four or five reservoirs and one river system), and only one of these, the Nishiyama Reservoir, may have been slightly contaminated; however, the dose reconstruction assumes that all Nagasaki troops got all their drinking water from this contaminated reservoir.

In summary, after the most detailed research and meticulous dose reconstruction--using numerous assumptions which would maximize dose--no areas of concern or significant doubt can be identified, and the firm, well-substantiated conclusion is that the radiation doses received by members of the Hiroshima and Nagasaki occupation forces were negligible.

Health Effects of Radiation Exposure.

Over many decades, researchers of many nations have carried out extensive research into the health risks caused by ionizing radiation. This research has been so voluminous, detailed, and intensive that more is known about radiation and its health effects than about any other carcinogen. Numerous eminent scientific bodies, national and international, periodically review all known research and issue detailed scientific reports which summarize the current views of medical science on ionizing radiation injury.

Among these distinguished bodies are the International Commission on Radiological Protection (ICRP); the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR); the National Council on Radiation Protection and Measurements (NCRP); the National Academy of Sciences' Committee on the Biological Effects of Ionizing Radiation (BEIR); and the ABCC/RERF Foundation mentioned earlier.

These organizations--and the great majority of individual scientists--are in close agreement on the major aspects of the health effects of ionizing radiation. They differ to a small degree on some of the fine points. The consensus can be expressed as follows. It is known that exposure to high levels of ionizing radiation (e.g., 100 rem) causes adverse health effects. Although science does not have proof that exposure to low levels of ionizing radiation (e.g., a few rem) causes adverse health effects, it is assumed that this is so, and that the effects are proportional to the dose. The only type of adverse health effect believed to be caused by low-level exposures to ionizing radiation is a slight increase in the incidence of cancers that occur normally. This assumed increase is so small it has never yet been measured, thus there are slight disagreements as to its exact magnitude among the various distinguished scientific groups mentioned above.

A numerical example may serve to put this in context. This example is from the 1977 UNSCEAR report, however, it is quite similar to the numerical estimates of the other distinguished bodies. In any typical group of 10,000 Americans, our national cancer statistics tell us that about 1,600 will eventually die of cancer. These are "normal" cancer deaths, not caused by exposure to excess man-made ionizing radiation. This estimate of normal cancer deaths is so approximate that a variation by 50 or even 100 would not be regarded as abnormal. Thus a range of cancer deaths from about 1,500 to about 1,700 out of a typical group of 10,000 individuals would be regarded by medical science as being normal. Now, if each of the 10,000 individuals is exposed to one rem of man-made ionizing radiation, medical science assumes that statistically there will be one additional cancer death over the lifetimes of the 10,000 individuals. Thus if a variation in cancer deaths from about 1500 to 1700 is regarded as normal, and if the radiation exposure of each of the 10,000 individuals to one rem causes a statistical increase of only one death, it is easy to see why medical science has difficulty in identifying this effect with precision.

This numerical example also shows how minuscule is the health risk which members of the Hiroshima and Nagasaki occupation forces might face. Using Nagasaki as an example, more than 10,000 Marines were stationed in the vicinity and had the opportunity for some slight radiation exposure. The "worst case" exposure for any of these individuals is less than one rem. However, the average exposure (which is the important factor in health risk estimates), is in the very low millirem range. Thus in statistical terms, the expected number of cancer deaths from among the 10,000 individuals engaged in the Nagasaki occupation is possibly one-hundredth of one cancer death. At the same time, however, approximately 1,600 "normal" cancer deaths would be expected over the lifetimes of these 10,000 veterans. Thus the added risk from radiation exposure during the Japan occupation is so small as to be negligible--far less than many other risks which we all readily accept as a normal part of life.

One specific health risk deserves mention because it has received some recent publicity. This concerns a type of bone cancer known as "multiple myeloma." This is a fairly rare form of cancer which strikes late in life. Medical science believes multiple myeloma has a borderline relationship with exposure to ionizing radiation. That is, there are some indications that exposure to radiation may increase the risk of this disease, but science cannot yet be sure.

The recent concern has been based on the fact that four veterans of the Nagasaki occupation have been diagnosed as having multiple myeloma. This does not appear to represent an abnormal incidence of this disease. The following statistics from the National Cancer Institute are pertinent. If you start with 10,000 males, age 25, in 1945 (which approximates the Nagasaki Marines); then today, in 1980, about 7.7 deaths from multiple myeloma should have already occurred, based on normal statistics. In the next decade, the number of normal deaths from multiple myeloma from within this group can be expected to increase rapidly. By 1985 the total deaths should be about 12.5, and by 1990 about 19.3. Thus based on our research to date, the four multiple myeloma cases that are known are less than the number that would have been expected for a normal, non-radiation-exposed group of this age and size.

Strong support for this conclusion that Hiroshima-Nagasaki radiation exposures are not causing increased multiple myeloma comes from the extensive research of the ABCC/RERF. During the more than three decades since the bombings, researchers have maintained close follow-up on Japanese citizens who were in or near the cities at the time of the detonations. A 1979 ABCC/RERF technical report shows that of almost 33,000 Japanese who received a dose of one rem or less, no increase in multiple myeloma has occurred.

A final point might be made about health risk from radiation dose. Man has evolved through the ages in constant exposure to ionizing radiation. Cosmic radiation from the sun, and terrestrial radiation from naturally radioactive elements in the earth, bathe each of us continually, every day of our lives, in ionizing radiation. Our dose levels vary somewhat according to location. In the U.S., these range from a low of about 100 millirem per year (e.g., Louisiana) to a high of about 400 millirem per year (e.g., Colorado). The negligible health risk caused by radiation exposures at these low levels can be seen by the fact that researchers have never been able to detect any increased risk of cancer in locations where the annual radiation dose is four times greater (400 millirem rather than 100 millirem), in spite of having a vast data base.

Conclusions.

In summary, DNA's extensive research over the past ten months has disclosed no basis for concern by veterans of the Hiroshima and Nagasaki occupation force over an increased risk of adverse health effects.

The extensive radiation measurements and soil sample analyses taken by numerous Japanese and U.S. scientists in the weeks following the bombings are still available. These readings and subsequent radiation measurements and sampling, have formed the basis for intensive research over the past 35 years by Japanese and U.S. scientists of every aspect of the bombings and the radiation aftereffects. The Japanese and U.S. Governments--with the National Academy of Sciences managing the U.S. participation--have supported, stimulated, and advanced this research, until the radiation aspects of the bombings and the related health effects are one of the most thoroughly researched topics known to science.

Likewise, the history of the U.S. occupation of Japan is well documented in Army, Navy, and Marine Corps archives. It is known which units were present, when they arrived, where they were stationed, what their missions were, and when they departed.

From the above data, detailed technical dose reconstructions can determine the maximum possible radiation doses that might have been received by any individuals. Using all possible "worst case" assumptions, the maximum possible dose any individual serviceman might have received from external radiation, inhalation, and ingestion is less than one rem. This does not mean that any individual approached this exposure level. In fact, it is probable that the great majority of servicemen assigned to the Hiroshima and Nagasaki occupation forces received no radiation exposure whatsoever; and that the highest dose received by anyone was a few tens of millirem.

As regards health effects of this dose, all distinguished national and international groups of scientists whose views are regarded as authoritative in the field of ionizing radiation injury agree that the health risk from a dose such as this is negligible--

so small statistically that it cannot be expressed in meaningful terms.

While these well-established facts appear quite conclusive, nevertheless DNA is continuing its research into all aspects of the Hiroshima-Nagasaki occupation.

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